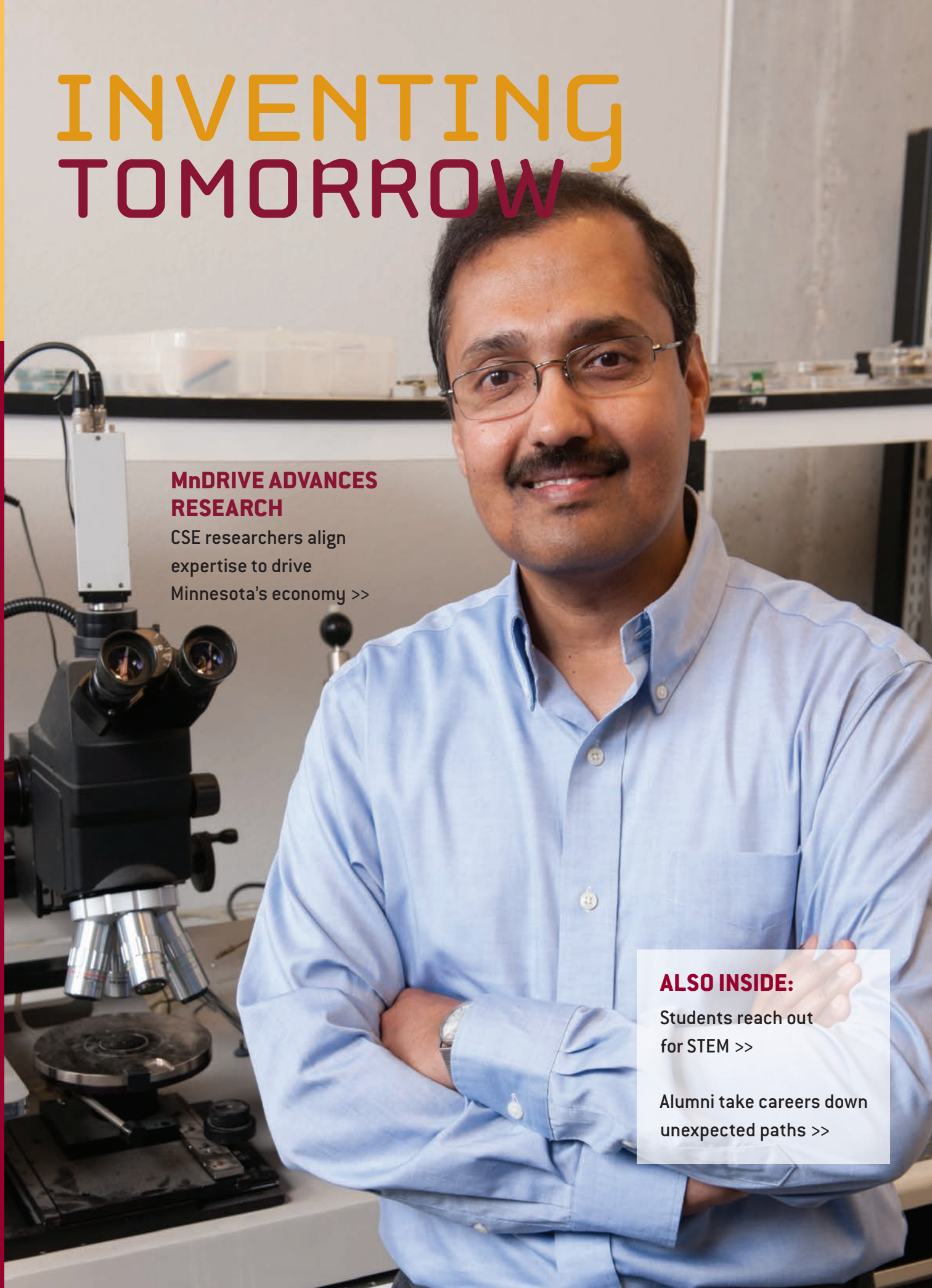
University of Minnesota

A MAGAZINE FOR ALUMNI OF THE COLLEGE OF SCIENCE AND ENGINEERING | FALL 2014

INVENTING TOMORROW



MnDRIVE ADVANCES RESEARCH

CSE researchers align expertise to drive Minnesota's economy >>

ALSO INSIDE:

Students reach out for STEM >>

Alumni take careers down unexpected paths >>

INVENTING TOMORROW

Fall 2014
Vol. 39, No. 1

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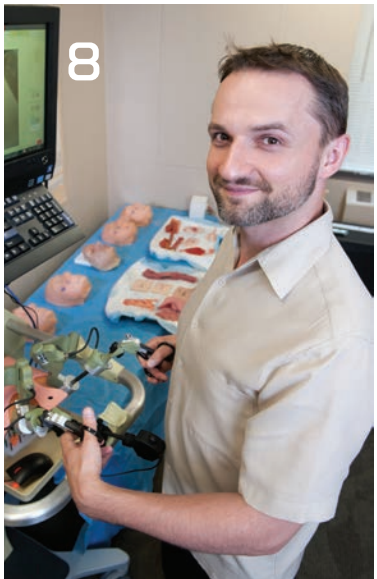


fall **2014**

INVENTING TOMORROW

DEPARTMENTS

ON THE COVER

Rajesh Rajamani is developing sensors for medical and automotive applications supported by MnDRIVE funding. • 8

PHOTO BY JAYME HALBRITTER

FROM THE Dean

Steven L. Crouch

We're sowing the seeds for future success

This past spring, the Minnesota Legislature approved funding to renovate the Tate Laboratory of Physics' obsolete labs and antiquated classrooms into vibrant, flexible spaces to bolster instruction and research.

As an avid gardener, I've learned to be patient. After planting seeds in the spring, it takes months to see the fruits of my labor. If I've put in the time and effort, there will be a bountiful harvest in the fall. My job as dean of the University of Minnesota's College of Science and Engineering isn't so different.

Over the last several years, we've worked hard to provide an environment where our research and education programs can grow. This past spring, we opened our new Physics and Nanotechnology Building, which will significantly increase the University's opportunities for collaborative research in the important area of nanotechnology. We unveiled a newly renovated St. Anthony Falls Laboratory this fall that will improve research in energy and the environment. We are opening the Gore Annex, a new addition to Amundson Hall, later this fall to expand undergraduate education in chemical engineering and materials science.

> "Over the last several years, we've worked hard to provide an environment where our research and education programs can grow."

But we're not done yet. This past spring, the Minnesota Legislature approved funding to renovate the Tate Laboratory of Physics' obsolete labs and antiquated classrooms into vibrant, flexible spaces to bolster instruction and research for the School of Physics and Astronomy and the School of Earth Sciences. Tate renovations are expected to begin this coming spring. We are also nearing completion of a new robotics lab in Hasselmo Hall. These infrastructure improvements are just the beginning of our seeds of success.

In this issue of *Inventing Tomorrow*, we clearly see that it takes more than buildings to be successful. The innovation and drive of our faculty, students, and alumni are the true measure of our achievements.

In the story "MnDRIVE Advances Promising Research," we highlight innovations by CSE faculty who are aligning their expertise with Minnesota's emerging industries to help drive the state's economy. In 2013, the State Legislature invested in Minnesota's Discovery, Research and InnoVation Economy (MnDRIVE) Initiative. CSE is leading the effort in the focus area of robotics, sensors, and advanced manufacturing. Already we're seeing new collaborations in areas ranging from agricultural robotics to new tools used in medical applications.

In the story "The Road Less Traveled," we show how the seeds of curiosity planted in our alumni during their education at the University has led them down unexpected paths to successful careers as product developers, business owners, and as leaders in international development.

In the story "Reaching Out for Science and Engineering," our current CSE students demonstrate how they are paying it forward by working to inspire younger students to become the innovators of tomorrow and make a difference in the world.

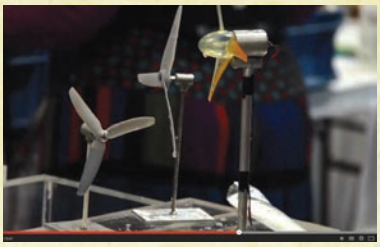
In our Retrospect story "Kolthoff Recognized for Pioneering Work," we see how some of legendary professor Izaak Kolthoff's work transformed analytical chemistry. Today analytical chemistry is used in fields as varied as clinical medicine, environmental studies, forensics, and food and drug safety.

A Confucius quote says, "If you think in terms of a year, plant a seed; if in terms of ten years, plant trees; if in terms of 100 years, teach the people." That's what we are all about at the University of Minnesota. ■

RECOMMENDED Extras | *on the Web*

To see these videos and more featuring College of Science and Engineering faculty, students, and alumni, visit our page on YouTube at **youtube.com/umncse**.

Hydrokinetic energy to power our future



Researchers at the University of Minnesota teach kids the science behind hydrokinetic energy at the USA Science and Engineering Festival.

Google's Project Tango

CSE researchers are helping Google create the smartphones of the future in an effort called Project Tango.

"WHY?" a show about science in the Twin Cities

Chris Leighton, CSE professor of materials science and engineering, is featured in a science program that explores the fascinating research being done in the Twin Cities.

U of M students power vehicle with sunshine and PTC Creo

Watch how the University of Minnesota Solar Vehicle Project team partnered with PTC, Inc. to meet its recent challenge.

Minnesota-style SpotFixing!

A University of Minnesota student team gives a facelift to 300 feet of ugly wall on Lavelle Road in Bangalore, India.

UMN Physics and Nanotechnology Building grand opening

The University of Minnesota launched a new era of excellence with the Grand Opening of the new Physics and Nanotechnology Building this past spring.

We're online!

The College of Science and Engineering's *Inventing Tomorrow* publication is available electronically.

To view an interactive online version of the current *Inventing Tomorrow* or to see past issues, visit our archives at:

cse.umn.edu/inventing tomorrow

Extreme Makeover: St. Anthony Falls Laboratory showcases $16M renovation

AFTER NEARLY FOUR YEARS of planning and reconstruction, the University of Minnesota's College of Science and Engineering celebrated a $16 million renovation of its 76-year-old St. Anthony Falls Laboratory (SAFL).

The renovation was made possible with $7.1 million in federal stimulus money from the National Science Foundation and state funds that were part of the University of Minnesota's allocation for Higher Education Asset Preservation and Replacement (HEAPR).

SAFL was originally built in 1938 as a project of the federal government's Works Progress Administration.

Fotis Sotiropoulos, SAFL's director and civil engineering professor, says the lab was built to take advantage of the Mississippi River's rushing currents as they cascade over St. Anthony Falls. The unique location made it a cutting-edge facility when it first opened.

The lab has drawn scientists from around the world to work on innovative solutions to the world's environmental, water resource, and energy-related problems.

However, after more than seven decades, SAFL was showing its fair share of wear and tear. The facility also had no working elevator or central air control systems, the latter of which greatly hindered research.

"The lack of climate control essentially compromised our ability to do precise experiments at certain times of the year," Sotiropoulos said.

With the renovation, existing facilities have been enhanced to improve research quality in wind-power efficiency and reliability; water-power energy devices and their environmental impact; biofuels focusing on bioreactors using algae; and environmental restoration and management, including streams, rivers, and deltas.

The renovation also allows researchers, practitioners, and a broad spectrum of learners to participate in SAFL through collaboration and virtual experiments.

"What we would like to do is provide an experience where somebody, wherever, can sit on a terminal and work with somebody here in real time," Sotiropoulos said.

Now with modern facilities, researchers are forging ahead on their studies, which include offshore wind turbines, algae used in biofuels, medical devices, and waterway restoration.

"Since its inception, the laboratory has been a leader in science-based solutions to major environmental and energy related problems through research, education, and outreach. This renovation enables us to continue and expand our leadership role well into the 21st century," Sotiropoulos said.

A gala reopening and ribbon-cutting ceremony was held on Sept. 17, 2014 to celebrate the $16M renovation of St. Anthony Falls Laboratory, a one-of-a-kind facility for environmental and energy research near downtown Minneapolis.

PHOTOS BY RICHARD G. ANDERSON

Study finds people of color live in neighborhoods with more air pollution

UNIVERSITY OF MINNESOTA RESEARCHERS, in a first-of-its-kind study, found that on average nationally people of color are exposed to 38 percent higher levels of nitrogen dioxide (NO^2) outdoor air pollution compared to white people.

Entitled "National patterns in environmental injustice and inequality: Outdoor NO^2 air pollution in the United States," the study was recently published in *PLOS ONE*.

Nitrogen dioxide comes from sources like vehicle exhaust and power plants. Breathing NO^2 is linked to asthma symptoms and heart disease. The Environmental Protection Agency has listed it as one of the seven key air pollutants it monitors. The researchers studied NO^2 levels in urban areas across the country and compared specific areas within the cities based on populations defined in the U.S. Census as "nonwhite" or "white."

The health impacts from the difference in levels between whites and nonwhites found in the study are substantial. For example, researchers estimate that if nonwhites breathed the lower NO^2 levels experienced by whites, it would prevent 7,000 deaths from heart disease alone among nonwhites each year.

"We were quite shocked to find such a large disparity between whites and nonwhites related to air pollution," said Julian Marshall, civil engineering associate professor and co-author of the study. "Our study provides a great baseline to track over time on important issues of environmental injustice and inequality in our country."

This is the first study to use satellite observations, measurements by the Environmental Protection Agency, and maps of land uses to explore disparities in exposure to air pollution for the U.S. nationwide, including both rural and urban areas, with comparisons by city, county, state, and region.

University solar car finishes second in American Solar Challenge

THE UNIVERSITY OF MINNESOTA Solar Vehicle Project team finished second overall in the 2014 American Solar Challenge last summer.

The student group was among teams from around the world that designed, built, and drove a solar-powered car more than 1,700 miles for eight days across the U.S. Out of 24 teams initially in the competition, only 10 passed all of the requirements necessary to compete in the race, which began in Austin, Texas and ended in Minneapolis on the University of Minnesota campus.

The team finished with a total elapsed time of 45 hours, 19 minutes, and 9 seconds over the eight days. First-place University of Michigan finished the race in 41 hours, 27 minutes, and 29 seconds.

Materials for the vehicle were funded primarily through cash donations and in-kind donations of parts and materials. In addition to the University of Minnesota College of Science and Engineering, major sponsors of the University of Minnesota's solar car include 3M, Altium, ANSYS, Cirrus Aircraft, Delta Airlines, IAR Systems, PAR Systems, PTC, Segger, and SunPower.

PATRICK O'LEARY

Goldy Gopher and the entire Solar Vehicle Project team escort the University of Minnesota solar car, Centaurus III, across the finish line. The team placed second overall in the 2014 American Solar Challenge, which ended near TCF Bank Stadium on the University of Minnesota campus.

In all, about 50 College of Science and Engineering students were part of the team, and about a dozen of them participated in the cross-country race.

For those students who work on the project, it's a time-consuming undertaking that gives them hands-on experience working with other engineering students from a range of disciplines.

CSE professors named Titans of Technology

TWO COLLEGE OF SCIENCE AND ENGINEERING professors are among the top technology professionals in the state to receive 2014 Titans of Technology awards by the *Minneapolis-St. Paul Business Journal*.

Arthur Erdman, mechanical engineering professor and director of the University of Minnesota Medical Devices Center, was recognized in the Technology Advocate category for his outstanding leadership in assisting, advancing or accelerating the performance of technology companies and the technology community.

Jian-Ping Wang, electrical and computer engineering professor and director of the Center for Spintronic Materials, Interfaces, and Novel Architectures based at the University of Minnesota, was recognized in the Technology Inventor category for his accomplishments in creating breakthrough ideas, processes, or products.

To view the full list, vist the *Minneapolis-St. Paul Business Journal* website at: **z.umn.edu/csetitans**

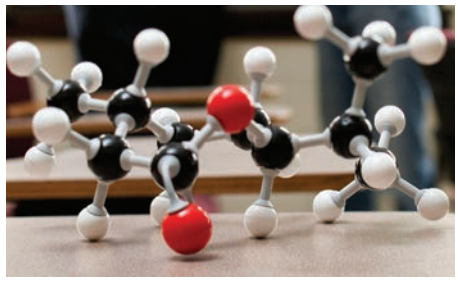
University's Center for Sustainable Polymers receives $20 million NSF grant to pioneer next generation of plastics

THE UNIVERSITY'S Center for Sustainable Polymers (CSP) has been awarded a $20 million grant over five years from the National Science Foundation to innovate next-generation plastics and materials. The center is one of only eight NSF Centers for Chemical Innovation in the entire nation.

The Phase II Center for Chemical Innovation program represents one of the most significant investments by the NSF's Division of Chemistry. The Center for Sustainable Polymers draws together top researchers from the University of Minnesota, Cornell University, and the University of California, Berkeley, along with more than 30 companies nationwide.

"There are biobased plastics that are already in the market, but our goal is to make them lower cost and higher performance to compete with plastics developed from non-renewable sources," said Marc Hillmyer, the center's director and CSE chemistry professor. "Our research will accelerate these discoveries and, with help from industry partners, we expect to realize the translation of our work to products in the market."

Since its beginning, Center for Sustainable Polymers researchers have built important partnerships with industry. To date, 32 companies have pledged their support, and the Center will continue to build its base of industrial partners.



"Some of the very best science is done when researchers with diverse backgrounds and perspectives work together to tackle the most challenging problems," said University of Minnesota Department of Chemistry Chair William Tolman. "With the granting of Phase II support by the NSF and the strong partnerships among faculty and students in the Department of Chemistry and the Department of Chemical Engineering and Materials Science at the University of Minnesota, our collaborators at UC Berkeley and Cornell, and the large group of industrial affiliates, the CSP is extraordinarily well-positioned to make innovative discoveries at the forefront of chemistry."

U of M officially opens state-of-the-art Physics and Nanotechnology Building

THE UNIVERSITY OF MINNESOTA officially opened its new $84.5 million Physics and Nanotechnology Building on the University's East Bank in Minneapolis after more than two years of construction.

Housing both the College of Science and Engineering's School of Physics and Astronomy and the Minnesota Nano Center, the 144,000-square-foot building includes 43,000 square feet for 40 modern and highly flexible physics laboratories and laboratory support space. It also features an unusual "high-bay" lab for large-scale physics experiments and more than 15,000 square feet for nanotechnology research, including a 5,000-square-foot clean room with five Class 100 work bays.

In the new space, the Minnesota Nano Center offers expanded facilities for nanotechnology applications in biology, medicine, and advanced materials. This research includes multiple disciplines across the University and in industry.

The building accommodates 200 faculty, post doctorate, graduate students, and visiting researchers, ranging from nanotechnology researchers studying the ultratiny to cosmologists probing the Universe's origins. More than 100 researchers from dozens of departments in several colleges throughout the University will also use the facilities. In addition, about 250 people from business and organizations nationwide currently use the University's nanotech facilities.

University officials say the Physics and Nanotechnology Building significantly increases the University's opportunity to support interdisciplinary research, its impact on solving real-world challenges with breakthroughs that will advance research, and its ability to educate the next generation of high-tech workers.

Zimmer Gunsul Frasca Architects, LLP, in association with Architectural Alliance, designed the state-of-the-art building, and Mortenson Construction served as general contractor.

PATRICK O'LEARY

Adorning the front of the new Physics and Nanotechnology Building are statues of a woman and man kneeling in meditative pose. Quantum physicist-turned-sculptor Julian Voss-Andreae created the two large-scale sculptures titled "Spannungsfeld" for the building. The artwork projects solidity and strength, like the stainless steel and granite they are constructed from, until you move directly behind or in front of one. Then they disappear, and one can see through them. "My design for this installation is inspired by a view of the human body through the lens of quantum physics," Voss-Andreae said. "Quantum physics lies at the heart of practically everything we encounter in the world, ranging from virtually every aspect of current high technology to the miracle of life itself." To view a video of the new space, visit **z.umn.edu/pan.**

U of M completes NOvA experiment neutrino detector

REIDAR HAHN

THE UNIVERSITY OF MINNESOTA recently celebrated a major milestone when it completed its role in building a 14,000-ton detector in northern Minnesota that could yield important information about the beginning of the Universe.

More than 700 University of Minnesota undergraduate students in 24 different academic majors built the detector over four years in a 125,000-square-foot warehouse in Minneapolis.

One of the largest plastic structures in the world, the detector is designed to detect sub-atomic particles called neutrinos. The neutrinos are shot out in an invisible beam to the detector from 500 miles away at a U.S. Department of Energy lab in Chicago.

Neutrinos are abundant in nature, but they very rarely interact with other matter. Studying them could unlock clues about the beginning of the Universe.

The NUMI Off-Axis electron neutrino Appearance, or NOvA, is a $278 million initiative involving 39 universities and laboratories in seven countries, with primary support by the U.S. Department of Energy Office of Science.

The University of Minnesota operates the detector under a cooperative agreement with the U.S. Department of Energy's Office of Science. The NOvA lab completed all requirements for full operation this fall.

New research finds Adélie penguin population rising

RESEARCHERS from the University of Minnesota and Stony Brook University have conducted the first-ever global census of Adélie penguins, which shows the population is 3.79 million breeding pairs or 53 percent larger than previously estimated. Their findings were recently published in *The Auk, Orinthological Advances.*

According to the researchers, the number of Adélie penguins living in the region has long been viewed as a key indicator species to monitor and understand the impact of climate change and fishing in the Southern Ocean.

Using high-resolution satellite imagery, the researchers applied a new method that permits regular monitoring of Adélie penguins across their entire breeding range and by extension the health of the Southern Ocean ecosystem.

The study finds Adélie populations at the global scale appear to be growing. Key to identifying the colonies—including the discovery of 17 populations previously not known to exist—was using satellite imagery to pinpoint the spectral characteristics of the excrement (called guano) of Adélies, a way to clearly identify the species' breeding grounds.

"We now have an important population baseline for Adélie penguins," said Michelle LaRue, co-author on the study and researcher in the University's Department of Earth Sciences. "Our methods also allow for annual, regional-scale comparisons of population trends that can more precisely inform us about ecosystem health and subsequent sustainability and conservation measures."

MICHELLE LARUE

Study uses blizzard to measure wind turbine air flow

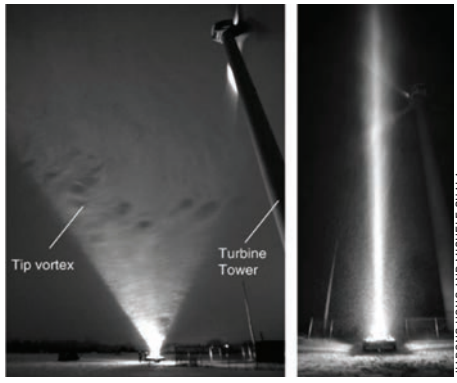
IN A FIRST-OF-ITS-KIND STUDY, University researchers have harnessed the power of a blizzard to study airflow around large wind turbines. The research, recently published in *Nature Communications,* is essential to improving wind energy efficiency, especially in wind farms where airflows from many large wind turbines interact with each other.

The U.S. Department of Energy estimates energy losses in wind farms to be as high as 10-20 percent and identifies complex airflows created by the turbines as the major culprit for these losses. As wind turbines have grown to more than 100 meters tall, field research in real-world settings has become more difficult.

"In the lab we use tracer particles to measure airflows of wind turbine models in wind tunnels, but our research was extremely constrained by an inability to measure flows at the large scale," said Jiarong Hong, a mechanical engineering assistant professor and lead researcher.

During harsh blizzard conditions in the middle of the night, the researchers set up a large searchlight with reflecting optics to generate a gigantic light sheet next to a 130-meter-tall wind turbine to illuminate the snow particles in a 36x36-meter-high area.

They videotaped the snow particles as the wind turbine spun to show airflow patterns. This video was digitized and synchronized with wake flow and load data from the fully instrumented research wind turbine. Results showed the technique was successful in measuring the turbulence of the airflow structure around the wind turbine. Visit **z.umn.edu/windvideo** to view video.



JIARONG HONG AND MICHELE GUALA

Researchers braved blizzard conditions to generate a gigantic light sheet next to the 130-meter-tall wind turbine to illumnate the snow particles.

University of Minnesota receives NSF grant for student innovation and entrepreneurship

THE UNIVERSITY OF MINNESOTA has landed a National Science Foundation I-Corps Site award, a grant that will help its science and engineering students take their discoveries out of the lab and the classroom and into the marketplace.

The $300,000, three-year grant will support expansion of the University's Minnesota Innovation Corps (MIN-Corps), including support for MIN-Corps' STARTUP course, an intensive course in which students test business model assumptions and receive recurring feedback from instructors and mentors. The grant also funds seed grants for student entrepreneurs and their teams to explore commercialization of promising ideas. Micro grants of about $3,000 will be available for up to 30 teams per year.

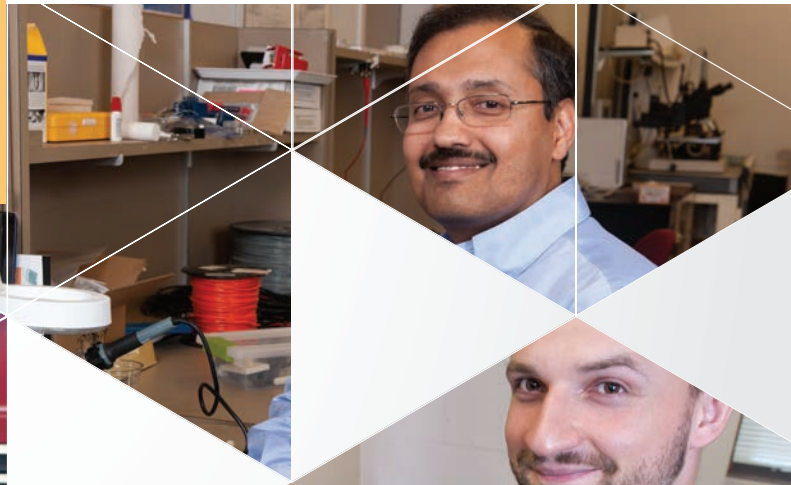
Across the University, there are 23,000 students and 2,500 faculty members in STEM programs. During the 2012-13 academic year, there were 331 new inventions disclosed, 148 new patent filings, and 14 startup companies launched. All of these numbers are record highs for the University of Minnesota, indicating strong upward trends in both innovation and technology commercialization.

"The NSF award provides a unique opportunity for the University to be part of a nationwide innovation network of shared resources, knowledge, and entrepreneurial expertise," said Mostafa Kaveh, College of Science and Engineering associate dean and lead on the I-Corps grant. "Ultimately, this program will not only benefit our student entrepreneurs, but it will help to advance Minnesota's innovation economy and develop the next generation of innovation leaders in the state."

MnDRIVE advances promising research

WRITTEN BY **RICHARD BRODERICK**
PHOTOS BY **JAYME HALBRITTER**

Researchers in the College of Science and Engineering are working to position Minnesota as a leader in key industries.



Most budgets adopted by the Minnesota Legislature are rooted in the here and now, designed to keep state agencies and programs afloat for the next couple of years.

But in April 2013, state lawmakers looked toward a longer-range future and did something far from humdrum. They established the Minnesota's Discovery, Research and InnoVation Economy (MnDRIVE) Initiative, a truly innovative program that provides $18 million per year in state funding. The funding is for initiatives that combine the University of Minnesota's strengths in four critical areas with the state's most important and emerging industries.

The four key areas are robotics, sensors and advanced manufacturing; global food ventures; advancing industry and conserving the environment; and discoveries and treatments for brain conditions. Understandably, the MnDRIVE Initiative has major implications for the College of Science and Engineering, especially in the realm of robotics, sensors, and advanced manufacturing.

"Basically MnDRIVE is the outcome of the tight integration between the University and Minnesota's economy and development, in particular the region around Twin Cities," observes Nikos Papanikolopoulos, a professor of computer science and engineering. "If we look at the business community in Minnesota, at companies both large and small, at doctors, and lawyers—a large percentage are University graduates. The University is not only the state's major educational force, it is also a major spur for regional economic growth."

"MnDRIVE started as a way of investing in the community by helping to strengthen the bonds between the University, business creation, and workforce development," he explains. "The University gets money from the state and it helps train the workforce. But even more so, the University tries to solve some challenging problems that local industry faces."

"MnDRIVE represents a collaboration between the University, our state, and the important areas of industry where we need to drive innovation," said Brian Herman, University of Minnesota vice president for research. "This initiative will help ensure the University remains competitive as a research leader by developing the technologies and work force of the future as we continue to plan for and resource innovation beyond the current, uncertain economic environment." The Office of the Vice President for Research is charged with implementing the program and providing oversight and measurement for the initiative.

The following profiles illustrate how researchers in the College of Science and Engineering are driving innovation through MnDRIVE.

Mapping the world: Stergios Roumeliotis

When visitors arrive at Stergios Roumeliotis' lab in the basement of Walter Library, they are apt to be greeted by graduate student Dimitrios Kottas holding a smartphone aloft.

"Follow me," he says with no further explanation. The experience that ensues is, in some ways, a step into the future. As the smartphone screen portrays a real-time, full-color, 3D moving image of the halls and stairways and book-lined rooms of Walter, faint white lines on the screen trace the exact route taken by Kottas and his entourage.

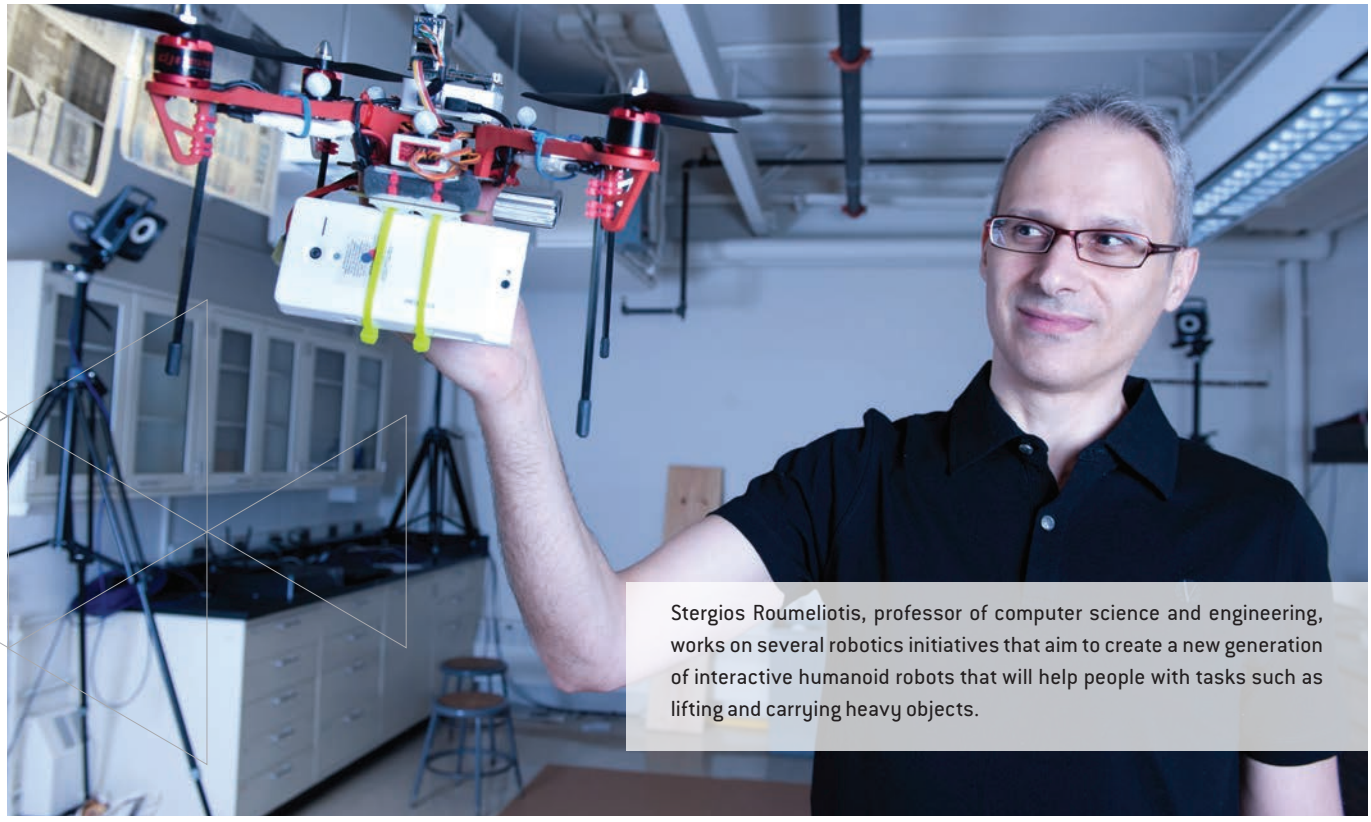
What Kottas is demonstrating is just one of several projects Roumeliotis, a professor of computer science and engineering, is conducting. In this case, a handheld device helps visually impaired individuals find their way around unfamiliar terrain. It is work for which Roumeliotis was awarded an NSF grant some five years ago.

Since then, two of his former doctoral students, Joel Hesch and Esha Nerurkar, have gone on to help lead similar work as part of Google's "Project Tango," a smartphone application that will offer full-color, 3D indoor images showing consumers exactly where they are and what people and things are nearby. In addition to hiring CSE graduates, Google recently named the University of Minnesota one of its academic partners in the project.

Roumeliotis also recently received a $3.5 million NSF grant as part of the agency's National Robotics Initiative. The money is funding research into "collaborative robotics," which aims to create a new generation of interactive humanoid robots that will assist people with a variety of tasks, such as lifting and carrying heavy objects. Roumeliotis is conducting the research with fellow CSE faculty member Demoz Gebre-Egziabher, as well as with investigators from several other universities.

"We're a robotics lab. That's what we do," said Roumeliotis, whose work in this area began some 10

> **"The University is not only the state's major educational force, it is also a major spur for regional economic growth here."**
>
> —NIKOS PAPANIKOLOPOULOS



Stergios Roumeliotis, professor of computer science and engineering, works on several robotics initiatives that aim to create a new generation of interactive humanoid robots that will help people with tasks such as lifting and carrying heavy objects.

years ago with research aimed at developing inertial and visual algorithms for use by NASA on its Mars rovers and spacecraft.

From there, he developed mapping devices to use on Earth where GPS cannot offer accurate data or where a finer order of mapping—millimeters rather than meters, as is the case with GPS—is needed. That, in turn, led to the research that began five years ago, now bearing fruit in "Project Tango." Today, Roumeliotis is also involved in developing navigation algorithms for quadrotors—small, four-rotor aircraft equipped with inertial and visual sensors—that can fly into enclosed spaces and send back real-time video of what's inside.

"Ground-based robots can go into a building looking for explosives or snipers but may get stuck on an obstacle or trigger an explosion," he points out. In similar situations, he explains, "You'll be able to fly [a quadrotor] into a second story window and get the same information without the risk."

"Whether it's a spacecraft that lands on Mars or a cell phone here in Minnesota, the common theme is how to find your way around," Roumeliotis said. "The hardware is the same, albeit of different quality, and the questions the software needs to answer are the same—where are we, how do we find our way, where do we want to go?"

Flying High: Demoz Gebre-Egziabher

Like his colleague and research collaborator, Roumeliotis, Demoz Gebre-Egziabher, professor of aerospace engineering and mechanics, is working on navigation systems for things that fly and things that roll on the ground. In addition to navigational hardware and guidance systems, Gebre-Egziabher's research group work focuses on developing algorithms to find your way around. In both cases, he uses UAVs—uninhabited aerial vehicles, or unmanned aircraft—as research tools.

"Our group's research has two themes," he said. "Using UAVs as test beds to develop new and novel ideas to improve safety and efficiency of passenger-carrying airplanes; the other is collaborating with local industry to develop UAVs as platforms for other applications like precision agriculture."

Currently, he's part of a research group developing systems that will allow UAVs to provide increasingly sophisticated uses both for designing navigation systems and for collecting data from the air on everything from traffic flow in cities to the growth and specific needs for water, fertilizer, pesticides, and herbicides of farm fields under cultivation. The latter use could revolutionize agriculture, targeting inputs and greatly reducing the amounts of fertilizer and other materials applied to fields, with obvious implications for improving yield while minimizing environmental damage.

"UAVs are flown without a pilot on board so they can be completely autonomous or piloted by someone on the ground, " he explains. UAVs, he points out, "come in all sizes, ranging from those as large as commercial jets to vehicles as small as a hummingbird."

Because UAVs are far less costly and dangerous to

Professor of aerospace engineering and mechanics Demoz Gebre-Egziabher is developing systems that will allow UAVs to provide increasingly sophisticated uses both for designing navigation systems and for collecting data from the air.

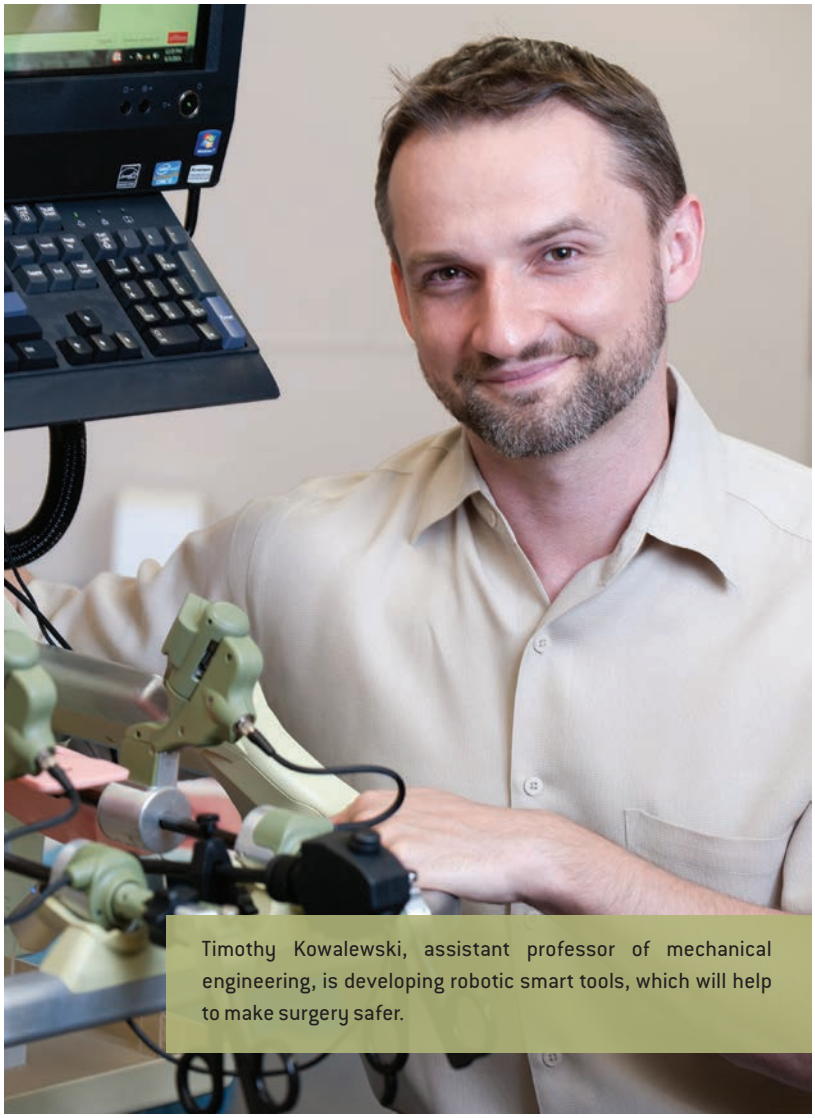
operate than manned aircraft, there is an intense interest to use them for a host of scientific and commercial applications.

"Among other things, our labs see UAVs as surrogate platforms for larger passenger- or cargo-carrying aircraft," he said. "There are many new ideas and technologies you might want to test but typically they're too costly and risky to try out on a full-scale aircraft carrying humans. So you apply ideas to UAVs, test them, and if they work, then scale them up to a larger plane."

Within that group, Gebre-Egziabher says, his own personal focus is "navigation and state estimation" or using UAVs to explore new ways to navigate and guide aircraft in ways that that could make them safer and more efficient, and to achieve this, by testing new ideas in cost-effective ways.

"If you look at the way electronics for aircraft are designed now, new gear technologies and concepts require a long testing period to ensure they are safe, effective, and don't have unintended consequences for use in manned aircraft," he said. This takes years and a considerable amount of money. UAVs hold out the potential of cutting that time substantially, while eliminating any risk to human life.

He points to the current state of GPS use on commercial airplanes, as an example of how UAV-based development holds out hope of great leaps forward. "Everyone uses GPS," he said. "However, commercial aviation has seen some of the slowest adaption of technology for safety-critical phases of flight such as landing. In fact, it has not fully adapted GPS, particularly in precision (automatic) landing applications." The reason? "GPS is considered relatively new and much testing must be done before they can get approval for its use in that application."



Timothy Kowalewski, assistant professor of mechanical engineering, is developing robotic smart tools, which will help to make surgery safer.

Smarter Surgery: Timothy Kowalewski

An estimated 100,000 Americans die each year not from cancer or heart disease or stroke but from medical mistakes, an appalling statistic for a society that prides itself on having the most technically advanced medical care in the world. The figure makes medical error the 10th leading cause of death in the United States.

Of that number, almost a third, about 32,000, are the result of surgical errors. Additionally, surgical errors that result in death, coupled with those in which patients survive injuries incurred during surgery, account for an estimated 4.2 million extra days of hospital stay every year. It's a figure that has staggering economic implications when one takes into account not only the average daily cost of hospitalization, but the productivity loss of employees taken off line by surgical mistakes.

This is where assistant professor of mechanical engineering Timothy Kowalewski enters the picture. As head of the Medical Robotics and Devices Lab, his mission "is to make surgeries safer."

With that goal in mind, Kowalewski follows a two-fold path. "We focus on the technology used in surgery and on the person using the devices created by that technology," he said.

First, Kowalewski's team focuses on developing robotic smart tools. These are small surgical instruments that can supplement the qualitative "art" of surgical judgment with quantitative, real-time information about a range of critical factors. This enables new technologies like an alarm warning of tissue injury before it occurs or tissue diagnostics at the tool tip during a procedure, like whether any unwanted, diseased tissue remains. Secondly, Kowalewski is working on the human side of the medical mistake equation—specifically, training and certifying practitioners.

> "We focus on the technology used in surgery and on the person using the devices created by that technology."
>
> –TIMOTHY KOWALEWSKI

"Measuring elasticity can be used for diagnosing tissue health in many applications. For example, with precise data, you can differentiate between tissues that have tumors and those that don't."

—RAJESH RAJAMANI

"Surgery is taught by trial and error," he observes. "One of our approaches is simulation, either through virtual reality or a physical simulator using realistic mock tissues that allow clinicians to learn and practice their techniques, making mistakes and learning from those mistakes before practicing on live patients."

Kowalewski's first application was in evaluating the skills of laparoscopic surgeons by capturing and analyzing their tool motion. His work was commercialized as the EDGE trainer by Simulab Corporation, based in Seattle, and is currently in use by the American Urological Association to create a skills certification exam. His current work employs *da Vinci* surgical robots, which are currently used in a wide range of minimally invasive operations. Equipping these instruments with sensorized "tissues," Kowalewski and his research and medical partners created what he calls a "high-stakes certification exam whose parameters are created by top surgeons."

"The test is called the Fundamentals of Robotics Skills for Surgery," Kowalewski explains. "It was created by an international consortium of leading surgeons who use robotic instruments with a few of us engineers."

"Skill evaluation is applicable to any kind of surgical robotics because all of them can store motion data during surgeries," he said. "That, in principal, can be used to monitor and improve people's skills."

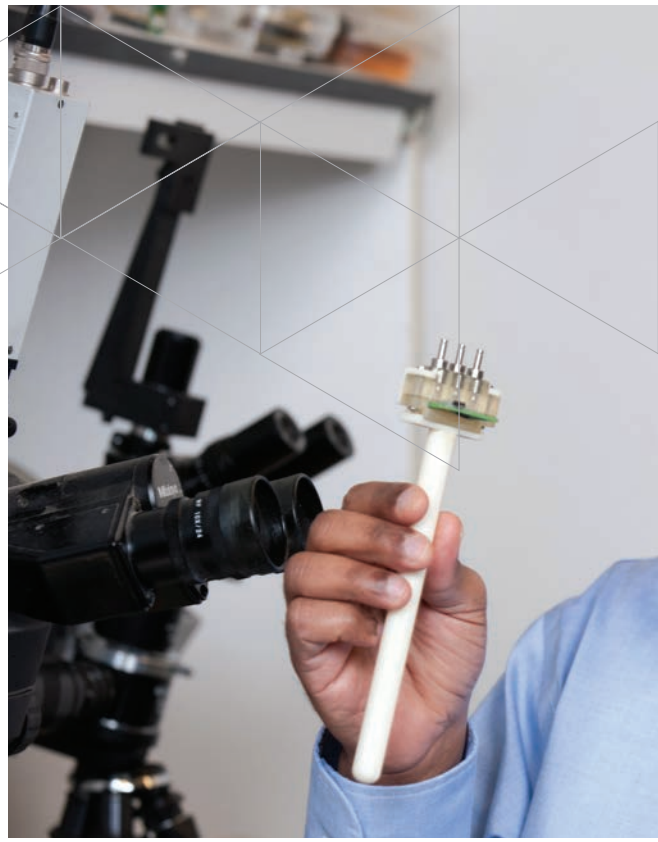
His specific research involves surgical robots with motion capture sensors. "This enables us to compare the videos and records of two different surgeons doing the same procedure and determine, quantitatively, which doctor is more adept at using robots during surgery. That data in turn will help to quantify what skills are needed and what works best in a particular surgical procedure."

Sensing and Estimation: Rajesh Rajamani

Mechanical engineering professor Rajesh Rajamani's research specialty is focused on electromechanical sensors that have medical or automotive applications. "I work on sensing and estimation systems," he said. "We build prototype sensors and develop estimation algorithms that can provide estimates of variables that you want to track in real time."

One of his many projects currently in commercial development with a business partner is supported by MnDRIVE funding. However, because it's still in the development stage, it's one which he cannot speak freely about beyond explaining that it involves using measurements of magnetic fields to estimate the position of ferromagnetic—steel and iron—objects.

Though the project will have biomedical applications, Rajamani said, "We are looking at the mechanical applications right now, in particular its use



for measuring piston positions in industrial equipment and mobile applications."

Among his other projects, Rajamani and his colleagues have licensed technology to a Minnesota startup called FocusStart. In this project, they have developed a handheld device to measure tension in the body's taut soft tissues. The device could have a revolutionary impact on orthopedic surgery, in particular for joint replacement surgery that is becoming increasingly common as the country's population ages.

In a nutshell, the FocusStart instrument will allow surgeons to measure tension in soft tissues quantitatively rather than by "feel." In turn, this will ensure bones and replacement joints align exactly, greatly reducing the wear of implant devices and improving the functionality of the replacement joint.

For instance, during knee replacement surgery, the probe would be used to measure and balance tension in the knee ligaments, leading to good restoration of knee function and a long lasting implant. Likewise, during hip replacement surgery, the probe would be used to measure tension in the abductor muscles to ensure the hip prosthesis is in balance and has the right amount of normal force to prevent both hip dislocation as well as uneven gait.

Another of Rajamani's patent applications involves an NIH-funded project for a urethral catheter

Mechanical engineering professor Rajesh Rajamani is working on electromechanical sensors that have medical or automotive applications.

capable of accurately measuring distributed urethral pressure at several different points simultaneously, while also measuring EMG signals, even while a patient is moving. Currently catheters can only measure pressure at one point in the urethra, and a patient must remain still during urodynamic tests. Especially in female patients, Rajamani's instrument will make it possible for urologists to pinpoint the exact source of incontinence, whether muscular or neurological, and treat the problem without guesswork.

Yet another of his projects—this one undergoing in vitro testing—is a flexible MEMS sensor that measures tissue elasticity.

"Measuring elasticity can be used for diagnosing tissue health in many applications," Rajamani explains. "For example, with precise data, you can differentiate between tissues that have tumors and those that don't. It could be used, for instance, to measure the health of knee cartilage during minimally invasive surgery, or to measure the pressure inside a compartment that the instrument is pushing against."

Rajamani came to the University of Minnesota from the University of California-Berkeley in 1998 where he specialized in estimation and control for mechanical applications. His expanded interest in biomedical applications comes as no surprise to anyone familiar with Minnesota's technological leadership—a leadership reflected in the MnDrive initiative itself.

"When I came here, I saw a lot of collaboration between the University of Minnesota Medical School, the College of Science and Engineering, and industry," he said. "Sensing and biomedical applications really took off for me after coming to Minnesota."

Inspiring the next generation

While University researchers address society's greatest challenges through the MnDRIVE initiative, a group of University of Minnesota students are inspiring the next generation of engineers as MnDRIVE Scholars.

KAYLA CHOATE

A MnDRIVE Scholar leads a hands-on project during Technology Day Camp, geared toward students, ages 11-13.

CSE's MnDRIVE Scholars are students focused on outreach efforts related to robotics, sensors, and advanced manufacturing. Their goal is to increase the number of students who plan to go into the engineering and computer science fields.

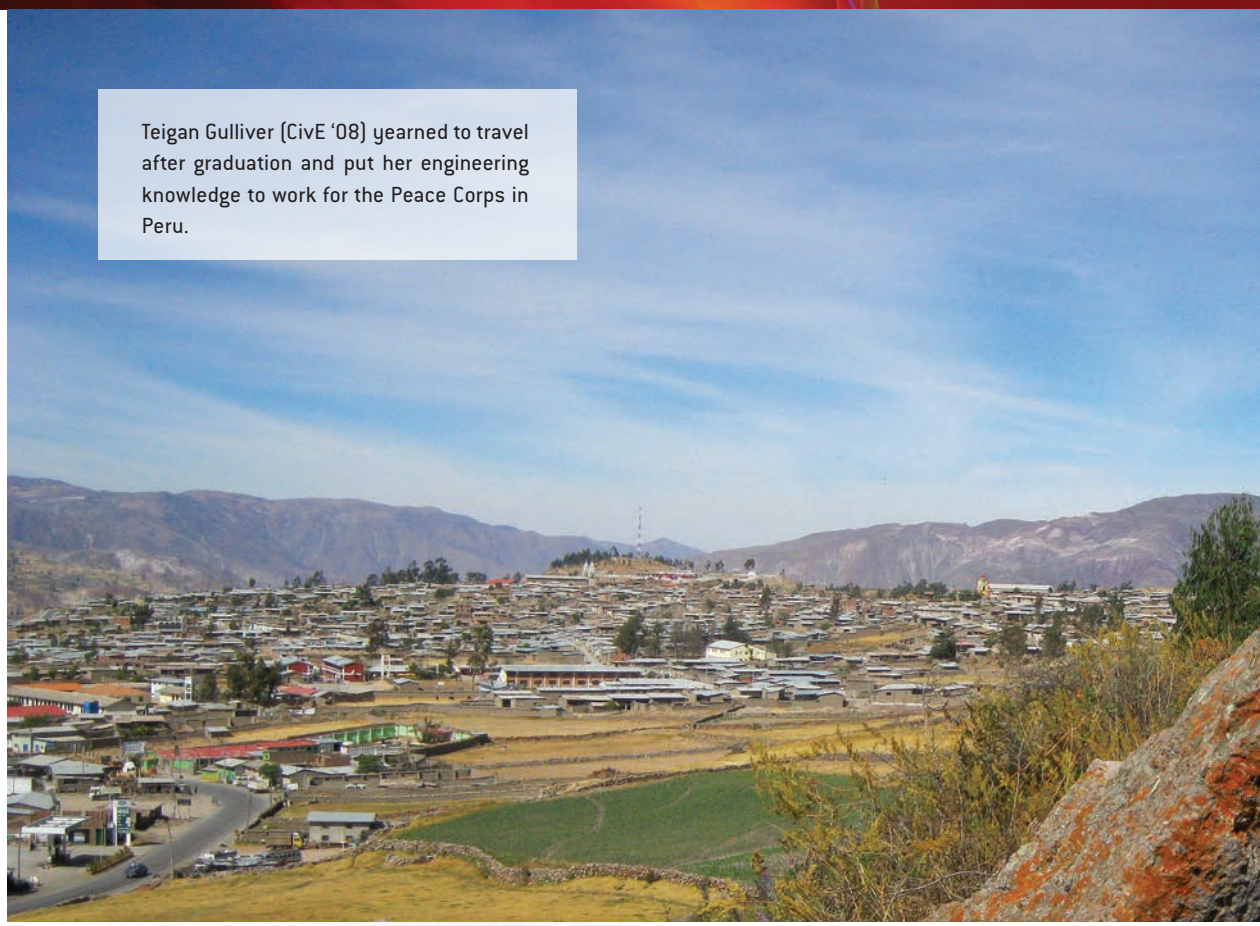
"Thus far, much of our outreach has been in robotics and programming, mainly due to the fact that these are the areas of expertise among the scholars," said Zofia Kaminski, a graduate student in mechanical engineering and MnDRIVE Scholar. "We also plan to focus on computer science and engineering in general."

Since being accepted to the program, the MnDRIVE Scholars—11 graduate and undergraduate students—have been involved in a variety of outreach activities with middle school and high school students working to spark their curiosity in engineering and computer programming. In addition to the Minnesota State Fair, Robotics Alley Conference, and Technology Day Camp, they participated in the recent CSE Expo, where they presented demonstrations on robotics and programming. (See related story beginning on page 18.)

The group also plans to get a foothold in local schools, the Science Museum of Minnesota, and collaborate with other organizations where they can have the highest impact. Part of their initiative is to develop a training seminar for teachers where they can learn about another side of engineering and science and its possibilities.

The MnDRIVE Scholars are addressing the entire gamut of outreach. They're looking at how to bring their expertise to different age groups, from middle school all the way up to graduate work; how to tackle different types of learning, not just hands-on but also more conceptual type of work; and they are focusing on the size of their outreach efforts, spanning the spectrum from one-on-one mentorships up to large classrooms.

"With engineering, you look at the world in a different way. You see how things are made, how they are designed, and how you can make them better," said Kaminski. "We want to show young people what they can do with good science and engineering skills and where these skills can take them."



Teigan Gulliver (CivE '08) yearned to travel after graduation and put her engineering knowledge to work for the Peace Corps in Peru.

THE Road Less Traveled

WRITTEN BY **GREG BREINING**

TECHNICAL SKILLS AND ROAMING CURIOSITY LEAD COLLEGE OF SCIENCE AND ENGINEERING ALUMNI DOWN UNEXPECTED PATHS

PHOTO PROVIDED BY TEIGEN GULLIVER

When one describes the stereotypical science and engineering student, what comes to mind? Studious. Hard-working. Practical. A Steady Eddie forging a path to a degree and long career.

But plans change. New circumstances require midcourse corrections. The dreams of youth change with time. Sometimes the certainty of the academic path opens to a world of uncertainty and exploration.

Scientists and engineers, despite the stereotype, aren't immune. They're dreamers, too, susceptible to the siren call of traveling off the well-worn path.

Reid Plumbo: Right on target

Eight years into a career with aerospace manufacturer Lockheed Martin, Reid Plumbo (Aero '05) suddenly switched jobs. One day he was working on a propeller for a British army surveillance drone. "Two weeks later, I was meeting with a vendor talking about the glass thickness of a picture frame," said Plumbo, now the lead product development manager for housewares at Target in Minneapolis.

The leap from aerospace engineering to housewares wasn't as great as it would seem. Whether engineering unmanned aircraft or designing cookware and fireplace tools, Plumbo said the job begins with a question: "What does this product have to do?" The British military aircraft had to fly and perform in subzero cold, broiling heat, and rough use. Target cookware had to survive—the dishwasher.

"These things needed to function, they needed to do what they said they were going to do on the label," Plumbo said. "And so when I came to Target I found that very natural."

Plumbo had piloted a course toward aerospace engineering ever since he was a kid, building models and flying radio-controlled aircraft. When he entered the College of Science and Engineering in 2002, he imagined he would be designing the next generation of fighter jets or commercial airliners.

"I was sure I could do it all by myself out of my notebook, just like a problem in my aerodynamics textbook," he said. "In reality, when I got there, it was way more collaborative than that." When he started at Lockheed Martin's Eagan, Minn. plant in 2005, he said, "I was designing the coupler for a pipe for a computer system for a rack of computer systems for an airplane."

He was taken aback by the project's narrowness but undeterred. His coupler project was short-lived. Soon he found himself on a team designing unmanned aircraft. For eight years, he worked with "a really talented group of people" developing drones with wingspans up to 16 feet, used for a variety of commercial and military purposes.

> "Serendipity combined with flexibility has been an incredible enabler in my career."
>
> —REID PLUMBO

RICHARD G. ANDERSON

After beginning his career in the aerospace industry, Reid Plumbo (Aero '05) moved to Target in Minneapolis where he now develops houseware products.

He discovered as much as he liked designing planes, he enjoyed leading people even more. "I like the more collaborative end of engineering rather than the heads-down, the grind-it-out-at-your-desk kind of engineering," Plumbo said.

Unfortunately, in 2010, Lockheed announced it would move its unmanned aircraft program to New York. "Being a Minnesota guy and having connections—I have family here and everything—I just didn't want to move," said Plumbo. "My wife, the same thing. Her family is here."

So he looked close to home, including Target, where his wife already worked. He liked the company and knew it needed engineers. "The big reason I wanted to do that was to learn something new and to explore that more collaborative side of engineering."

He landed a job with Target in 2011. Now he leads a team that designs kitchenware, fireplace tools and accessories, storage and organization products, and decorative hardware.

The challenge, he said, is not the difference in products, but the difference in working culture. Where once he was surrounded by engineers, now he is joined by industrial designers, marketing people, designers who specialize in sourcing and packaging, and others with their own language.

"When you're at an engineering company, you know how to communicate with other engineers," said Plumbo. "It's easy because you went to school with them, you grew up with them. We just get each other. You can show each other math and spreadsheets and things become obvious. When I came to Target, I realized those tools were not necessarily the right ones to use to communicate messages."

"Serendipity combined with flexibility has been an incredible enabler in my career," Plumbo said. "When I came to Target I had to learn to be flexible in new ways. I had to learn that there are people out there who aren't exactly like me. And I needed to learn to communicate with them."

Phil Chou and Grant Merrill: Smooth hoperators

When research chemists Phil Chou (Chem Ph.D. '92) and Grant Merrill (Chem Ph.D. '96) met in grad school at the University of Minnesota, they discovered a common interest. Little did they realize how decisively it would shape their later careers.

That's because many grad students had the same interest.

"You know, the graduate school experience definitely includes drinking our share of beer," Chou

Grant Merrill (Chem Ph.D. '96) and Phil Chou (Chem Ph.D. '92) gave up careers in academia and industry to run Dirty Hands Brewing Co. in Vancouver, Wash.

said with a laugh. "I certainly wasn't looking at it as a career at that point."

All that changed. These days Chou and Merrill have given up careers in academia and industry to devote their energies to running Dirty Hands Brewing Co. in Vancouver, Wash.

Chou earned his doctorate in organic chemistry at the University of Minnesota in 1992 (a few years ahead of Merrill). After postdoc work and an initial interest in an academic career, Chou switched his focus to industry, working for several years in research and development for a chemical company in Indiana.

One day he spotted a job ad for Miller Brewing in Milwaukee. "I thought that was kind of cool, so I applied for it, not really expecting to get the job because it was so different from what I was doing then," Chou said.

PHOTO PROVIDED BY PHIL CHOU

But he was hired and soon was learning about the chemistry of hops, the flowers of the hop plant that impart tangy flavor to beer. "I was definitely a beer drinker and thought it was just a real fun way to apply my education and training," he said.

Chou says his chemistry degree prepared him for the transition from plastics to beer. "The hallmark of any Ph.D. is that it gives you the tools to tackle problems that may be outside your area of expertise. Certainly that was the case with Miller."

Chou lost his job after South African Breweries bought Miller in 2002. He then joined E. & J. Gallo Winery. "I grew up in southern California so going back West was very attractive to me," he said. "Plus it gave me a chance to work with another alcoholic beverage—wine, which at the time I didn't really know much about."

He spent nearly 10 years researching the chemistry of winemaking, from vineyard to table. Meanwhile, he and Merrill, formerly a chemistry professor at the University of Texas at San Antonio, stayed in touch. Occasionally, Chou would mention the dream he nurtured of using his burgeoning knowledge of beverages to start his own brewery. It was a dream Merrill shared.

"We reached a point in our lives where we just got tired of working for large organizations with big bureaucracies," Chou said. "We just wanted to get out and do something on our own and build something on our own. We said, 'Let's try this. We're getting to the age where we've got to do it now, or it's never going to happen.'"

They researched the business, wrote a business plan, and considered locations to open their brewery. Both liked the Portland area. Unfortunately, Chou said, "There's a ton of competition in Portland." But just across the Columbia River was a different story.

> **"We just wanted to get out and do something on our own and build something on our own. We said, 'Let's try this. We're getting to the age where we've got to do it now, or it's never going to happen.'"**
>
> —PHIL CHOU

Editor's Note: Recently, we learned of additional CSE alumni brewing up hops. This past July, Deborah Loch (BME M.S. '91) and her partner, Jill Pavlak, opened up the Urban Growler, a microbrewery in St. Paul, Minn. In addition, CSE electrical engineering graduates, Jake Johnson ('07), Jeff Moriarty ('08), and George Kellerman ('07) added a taproom to the Tin Whiskers Brewing Co. in Lowertown St. Paul, which they founded in 2011.

"A lot of people with a civil engineering degree go into standard consulting... Some of these opportunities to work and travel the world in a non-traditional way can be pretty great."

—BRAD WEISS

"The more we looked into it, the better Vancouver, Wash., looked."

They found an old newspaper building, once occupied by *The Columbian*, and named their enterprise Dirty Hands Brewing for the ink-smudged fingers of newspaper workers and readers. "People either like or hate the name," said Chou. "But I'll ask them, are you going to remember the name? They always say 'yes'." It was a leap for both men—from high-paying jobs with benefits to working without a safety net. "It was definitely exciting, it was scary," Chou said. "Neither of us had ever worked a cash register. Yeah, it was definitely a risk."

Dirty Hands opened last November, with a taproom at street level, and all the brewery equipment in the basement, with tanks that can hold 108.5 gallons. The brewery has a total fermentation capacity of 434 gallons or 14 barrels. By contrast, Chou said, "Miller in a day spills more beer than we'll make this year."

Reflecting on the turns in his career, Chou offers this advice to would-be chemists. "Just learn as much as you can wherever you go and keep an open mind. Don't be afraid to take advantage of opportunities that present themselves."

Teigan Gulliver: Going global

Teigan Gulliver (CivE '08) declared her major in civil engineering her junior year. Yet, she didn't know what she wanted to do after graduation. "I had no idea," she said. "I don't think I ever actually thought about it."

But she was excited about the idea of travel. It was during her stint as an undergraduate research assistant for the Storm Water Assessment Project at the University's St. Anthony Falls Laboratory that a colleague suggested she get involved in foreign projects through Engineers Without Borders. She joined the group and soon traveled to Uganda.

For six weeks, she helped design and build a roof catchment system to provide drinking water at a rural school. In Uganda she met Peace Corps volunteers. "They talked about their service," Gulliver said. "It sounded like a lot of fun." After she returned to the United States, "I just applied." Her acceptance and assignment came through after graduation, as she was hiking the Appalachian Trail. She quit hiking and headed to Peru.

Gulliver took three months of intensive training to learn about the local culture and fortify her high school Spanish. She also studied some proven solutions to rural civil engineering challenges. "So for water and sanitation, we learned about all different kinds of latrines, biodigesters, things like that," she said.

She was sent to a small town near Ica on the Pan-American Highway, in the rain shadow of the mountains. "It's so dry there, even cactuses die," Gulliver said.

She stayed with a host family that included three sons roughly her age. The mother was a local politician who knew lots of people in town. "It was definitely a big help," she added.

Among her projects were a solar-powered pump for a school and a latrine of composting toilets for a rural community of about 20 homes. It was hardly an off-the-shelf project. "We were out there mixing mortar," Gulliver said. "There was a lot of hands-on experience."

Her experience in Peru taught her fluency in Spanish and gave her a chance to accomplish field projects. Gulliver returned to the United States in 2011, and now works for an engineering consulting firm in Colorado, designing and planning community water and wastewater treatment plants.

As Gulliver was weighing the possibility of working abroad, her mother gave her some good advice. "She said two things," Gulliver said. "First of all, don't

Before joining a consulting firm in Colorado, Teigan Gulliver (CivE '08) joined the Peace Corps and worked on a solar-powered water pump for a school and a latrine of composting toilets for a rural community in Peru.

PHOTO PROVIDED BY TEIGEN GULLIVER

Brad Weiss (CivE '12) is spending two years in Peru as part of the Peace Corps. Creating environmental awareness, he makes a house visit to encourage Peruvians to join a Healthy Homes project.

PHOTO PROVIDED BY BRAD WEISS

ever let fear be the reason for you to decide not to do something. You'll regret it the rest of your life if you don't try it because you're afraid. The second thing is you shouldn't feel rushed or in a hurry to start working because you'll have the rest of your life to work."

Brad Weiss: Adventurous engineer

Even though they graduated four years apart and didn't know each other at school, Gulliver's experience led Brad Weiss (CivE '12) to the Peace Corps in Peru.

As a fellow University of Minnesota civil engineering graduate, the similarity of their experience wasn't entirely a coincidence. Weiss learned of the Peace Corps through Gulliver's father, John Gulliver, a professor of civil, environmental, and geo- engineering in the College of Science and Engineering.

As he neared graduation, none of Weiss' initial job offers were very appealing. So he enrolled in graduate school (environmental engineering at Michigan Technological University) and a program called Peace Corps Master's International, which pairs graduate studies with the opportunity to serve abroad and develop an international academic project.

Like Gulliver, Weiss is serving a two-year hitch in Peru. Since November he's been living in Pomacochas in the foothills between the Amazon and the mountainous spine of the country. His room overlooks Laguna Pomachochas. "I love it here," Weiss said.

So far he has taught a summer school program on world geography that stressed environmental awareness to children ages 3 to 16. He also taught a computer class to fifth- and sixth-graders. He tried teaching basic programs such as Microsoft Word and Excel, but admits the kids had other priorities. "Just about every kid wanted a Facebook page," he said.

As he gets deeper into his service, Weiss has been organizing river clean-up days. A grant from the Minnesota Returned Peace Corps Volunteers paid for a weather station to teach about weather and climate change, as well as a video to create a public service announcement for local television. He has also been talking to officials about improvements in the water system to fix leaks and deliver potable water.

The best part of his experience, Weiss said, is that "every day is an adventure. You could be walking through the mountains conducting a water system inspection one day. The next day you could be in a formal meeting with the mayor and government officials. The day after that, you could fall into a swamp. All these things have happened to me."

"A lot of people with a civil engineering degree go into standard consulting, working for an engineering company or a private firm. But some of these opportunities to work and travel the world in a non-traditional way can be pretty great," he said. "I'm having the time of my life down here."

Reaching out FOR SCIENCE

WRITTEN BY **SILVA YOUNG**
PHOTOS BY **RICHARD G. ANDERSON**

CSE students are inspiring young students to become the innovators of tomorrow

When it comes to science and mathematics, many studies show students in the United States are falling behind when compared to students in other countries. Experts claim by the time they reach the high school level, students just aren't interested in science and math or find the subjects boring in the way they are taught.

University of Minnesota College of Science and Engineering students are doing their part to help with the problem. They're boosting middle schoolers' interest in the science, technology, engineering, and mathematics (STEM) subjects with an event called CSE Expo that they organized for the first time this past spring.

Described as a showcase of engineering creativity, CSE Expo was the brainchild of CSE students Ben Ihde, a physics and astrophysics major, and Jack Kilian, an electrical engineering major, who met as members of CSE's Tesla Works student group.

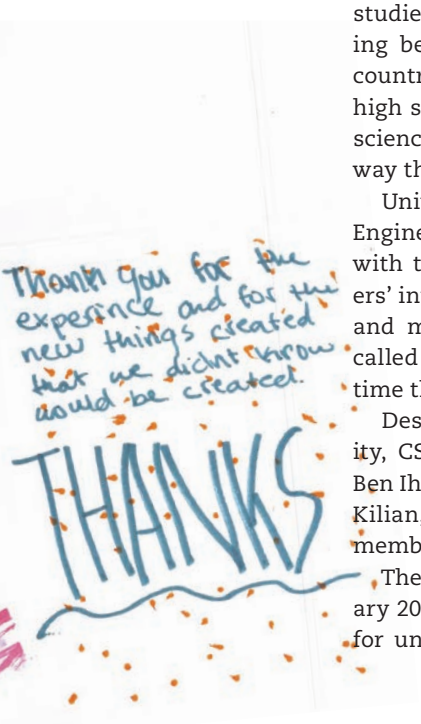
The wheels for the event started turning in January 2013, after Paul Strykowski, CSE associate dean for undergraduate programs, announced that CSE donors Nancy and Clifford Anderson would make grant money available for the right project. Their intent was twofold—get as many CSE students involved as possible and create an event that would impact the Minneapolis/St. Paul community.

Imagining the possibilities, Ihde and Kilian set out to win the grant through an application and ultimately secured the $200,000 award. They fine-tuned their idea to focus on middle school students.

"We knew the college didn't have any major outreach events targeted to middle schoolers," said Kilian. "We also thought we could have the greatest impression on that group because by the time you're in ninth grade, you're already starting to make those commitments in what kind of classes you'll be taking."

According to Susan Kubitschek, CSE assistant dean of student programs, outreach events like these help to show a broad range of science and engineering professions to students who may not have had much exposure to the STEM fields.

"We knew all middle school students wouldn't respond to the same things, so we wanted to show-



Student members of the Society of Physics Students use a bicycle wheel gyroscope—the conservation of angular momentum—to illustrate an important law of physics during the CSE Expo.

AND ENGINEERING

case different areas of science in order to change the limited perception some students may have of it," said Ihde.

The project really began to take shape once Mia Bronstein, a statistics major, was brought on board.

"She had done a similar event in high school for elementary schools so her experience was extremely valuable in figuring out logistics," Kilian said.

By November 2013, the trio had recruited four additional students. As the event's management team, they outlined their goals and objectives and structured the tasks that needed to be done.

Six months later, more than 2,000 Minneapolis/St. Paul middle school students experienced the first CSE Expo. Held on the University's East Bank Campus—Northrop Plaza and Church Street—the outdoor, open-house-style event featured 55 distinct hands-on projects, demonstrations, and shows, including flying robots and hovercrafts, rockets, and the Strandbeest, an 11-foot-tall pedal-powered walking machine.

"Nearly 300 CSE students built projects and presented them," said Bronstein. "I'm sure overall there were at least 500 who contributed in some way."

For all the hours spent—balancing academics and managing the CSE Expo—Ihde, Kilian, and Bronstein believe they pulled off an extremely successful event worthy of all the effort.

"Seeing that first school bus pull up was awesome," said Bronstein. "I was so excited. Watching all the middle schoolers interact with all the different projects that our students had built was so cool."

"I saw a couple middle schoolers go up to a booth. At first, they were hesitant because, at that age, you think you're too cool for anything," said Kilian. "I saw them slowly start to play with the demo and soon I could see smiles on their faces. It's really awesome to see them engage and be interested in science."

Plans for next year's CSE Expo begin this fall with Ihde, Kilian, and Bronstein taking the lead once again. They intend to invite about the same number of middle school students.

"This year, we had 2,000 students representing eight schools in the Twin Cities area, and registration was filled up in three days," said Bronstein. "Next year we hope to invite fewer students from each school, but we will invite more schools."

CSE Expo's ultimate goal is to spread the good word about science and engineering far and wide, and to inspire the next generation of scientists and engineers.

"Look at the problems the world is facing right now—climate change, depleting oil supplies, disease, and infrastructure. These are real concerns that need engineers and scientists," said Ihde. "If we can motivate a few people to get into civil engineering, chemistry, and physics, then we will have more people working on these problems years from now. I think that's one of the most impactful things we can do as undergraduates."

Many CSE student groups inspire young students in the STEM fields year-round. On the next pages, two CSE student groups show how they share their love of science and engineering with young students.

"Look at the problems the world is facing right now—climate change, depleting oil supplies, disease, and infrastructure. These are real concerns that need engineers and scientists."

–BEN IHDE

> "We enjoy sharing what we have learned and helping others develop interests in fields we feel passionate about."
>
> –MAGGIE NELSON

SWE brings STEM to girls

As one of the larger Society of Women Engineers (SWE) student chapters across the country with approximately 45 active members, the University of Minnesota's chapter participates in a number of outreach activities to boost the number of young women in the science and engineering fields.

At the CSE Expo, 22 SWE members showed middle schoolers how to make a Brush Bot, which involved attaching the head of a toothbrush to a small motor. Once connected, it created a small robot that moved randomly around the area.

"It's a simple, but exciting demonstration that kids can see and relate to," said Maggie Nelson, a CSE student and SWE's outreach director. "With this quick and easy project, we showed how creativity opens up a new world of opportunities."

In addition to participating in the CSE Expo, the group conducts a number of outreach activities throughout the year—the largest being "See Yourself in CSE" and "Technically Speaking" in partnership with CSE Admissions. With nearly 300 high school students and their parents in attendance last year, SWE members presented the various fields students can study in CSE, conducted experiments and demonstrations, hosted a Q&A panel for parents, and shared their experiences as women pursuing engineering degrees.

SWE members partnered with the Science Museum of Minnesota in a "Girls and Science" event that introduced science concepts, including Non-Newtonian fluids and chemical reactions, to elementary and middle school students. They also participated in SWE-Minnesota's Girl Scout Patch Day where Girl Scouts performed a variety of experiments to earn a merit patch reflecting what they have learned.

Society of Women Engineers (SWE) members show middle schoolers how quickly they can turn a toothbrush into a robot at the CSE Expo.

More than 2,000 Minneapolis/St. Paul middle school students experienced the first CSE Expo last spring. The event, featuring more than 55 demonstrations by CSE students, was an opportunity to inspire young students' interest in the science, technology, engineering, and mathematics fields.

"The highlight of last year's Patch Day was helping to build a bio-dome from rolled newspapers," Nelson said. "This coming year we hope to host a Girl Scout Patch Day on the University's campus in conjunction with the CEMS (Chemical Engineering and Materials Science) Women's Group."

Even more outreach is on the horizon. "We've been contacted about off-site visits to schools to lead small experiments and talk about the STEM fields," said Nelson. "There's a lot of interest and we hope to do more where possible."

"Giving kids hands-on experiences helps them learn and introduces them to a potential future career," she said. "For us, we enjoy sharing what we have learned and helping others develop interests in fields we feel passionate about."

Sparking students' physics curiosity

Whether they know it or not, the first science most children are exposed to is physics.

"Think of a simple ball—how it moves with air resistance, how long it takes to hit the ground, and what happens when it bounces off another object," said Luke DeMars, CSE physics student. "It's amazing how these simple objects can take on quite a complicated mathematical model."

Chris Nolting, a graduate student in astrophysics and member of the Society of Physics Students, demonstrates to middle schoolers how a Van de Graaff generator creates hundreds of thousands of volts of electricity.

That kind of thinking is what DeMars, an officer in the Society of Physics Students (SPS), wants to inspire in young students.

"Our group is trying to instill the idea behind scientific method. Nothing is spoon fed," said DeMars. "We present them with an idea, ask them questions, and slowly guide them through the process. With time and a little bit of patience, you can start to see some amazing results."

In addition to being a professional association for students interested in physics, the University of Minnesota chapter of the Society of Physics Students participates in nearly 20 outreach activities each year.

"We've helped Boy Scouts obtain their nuclear science merit badge, attended STEM career fairs, worked in magnet and charter schools, presented at the CSE Math and Science Family Fun Fair, and demonstrated at Tech Fest at The Works Museum in Edina, Minn.," said Becca McLaughlin, a CSE student in astrophysics and outreach coordinator for Society of Physics Students. "We're currently renting some of our demonstrations out to the University's Bell Museum of Natural History."

Serving as ambassadors for science and engineering, DeMars and McLaughlin are among CSE students who want to inspire young students and improve science curriculum.

McLaughlin, who developed curriculum this past summer for the Science Discovery Day Camp at the Bell Museum, believes students need to see things in action. "My physics class in high school was more like a math class. If students aren't super into math, they don't get it conceptually, so it's just more math to them."

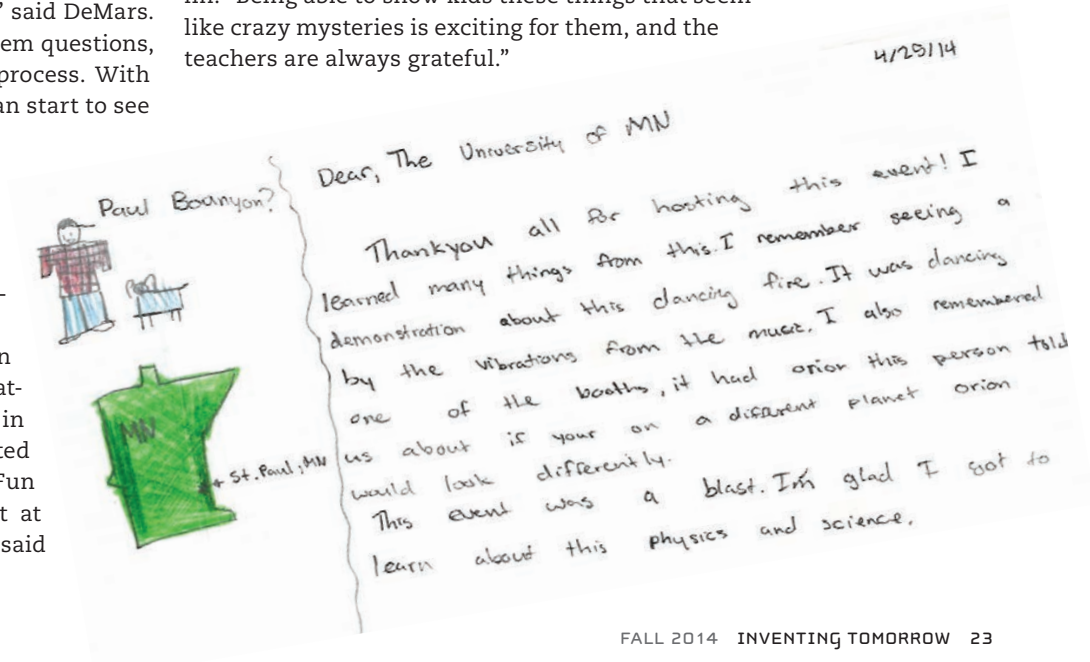
When it comes to teaching the STEM subjects at the elementary, junior high, and high school levels, DeMars feels things are kind of set on autopilot. "You have these standards that were set up years ago. They work so no one tries to improve them," he said. "That goes against the core idea behind STEM, which needs to continue growing. Teaching and presenting these ideas needs to grow as well."

That's why McLaughlin and DeMars are working on ideas to make their outreach program even bigger and better in the future.

"We have all the really cool toys—like a turntable and wheel that shows conservation of angular momentum or a Van De Graf generator to create static electricity—which isn't affordable for every grade school or high school classroom," said McLaughlin. "Being able to show kids these things that seem like crazy mysteries is exciting for them, and the teachers are always grateful."

"Being able to show kids these things that seem like crazy mysteries is exciting for them, and the teachers are always grateful."

—BECCA MCLAUGHLIN



Interested in a way to give back? Join the CSE Alumni Society Board

If you are interested in developing a stronger connection with the College of Science and Engineering, consider joining the CSE Alumni Society Board. The purpose of the board is to serve in an advisory capacity to the Dean of the college in matters concerning CSE alumni.

Qualifications and time commitment:

University Alumni Association paid members who are graduates, faculty, former students, friends or graduate degree holders with majors related to science and engineering are eligible to apply. Participation requires approximately three to five hours per month, including attending board meetings three times a year. Board members serve a three-year term and are eligible to serve two consecutive terms.

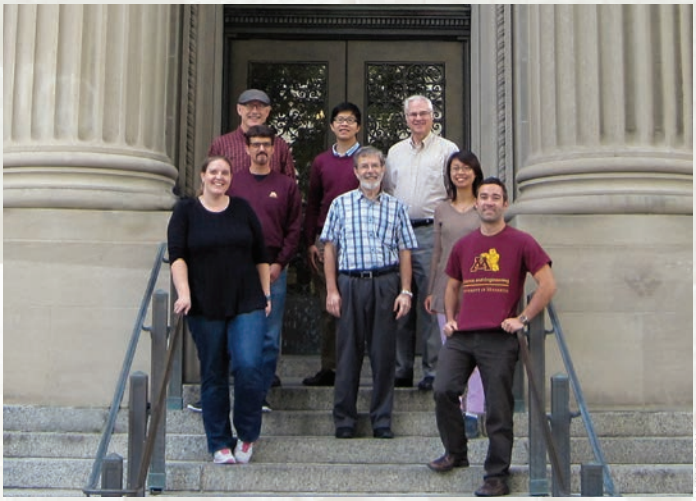
Primary duties:

- Understand the mission of the CSE Alumni Society and represent the society to alumni and the general public.
- Attend society board meetings and other society-sponsored events throughout the year.
- Provide leadership by chairing, co-chairing, or serving on one of the board's committees. Carry out the duties necessary of that committee.
- Serve as an advocate for the college and the University as appropriate during legislative sessions.
- Recommend candidates to serve as at-large board members to the society's nominating committee.

Currently 16 alumni are part of the board. They are:

- Kati Baltutis Vokes (ME '10)
- Don Craighead (ME '57)
- Rob Graber (CSci '86), Chair
- David Holt (BME '10)
- Adrienne Kelsey (ME '99)
- Steven Kopacek (EE '81)
- Danni Li (Chem Ph.D. '07)
- Chris Luo (ME '13)
- Pat McGuire (ME '81)
- Rich Newell (Chem Ph.D. '75)
- Stephen Ruiz (MatSci '13)
- Steve Savitt (EE '71, CSci Ph.D. '92)
- Ellen Sorenson (CSci '81, MSSE '88)
- Jerry Sosinske (EE '78)
- Raja Suresh (EE M.S. '75, Ph.D. '79)
- Greg Twaites (CSci '85)

If you are interested in becoming a board member, please contact Ann Terry, Director of Alumni Relations, at 612-626-1802 or asterry@umn.edu.



ANN TERRY

A few members of the CSE Alumni Society Board gather prior to their monthly meeting in Walter Library. Front row, Adrienne Kelsey, David Holt. Middle Row, Rob Graber, Steve Savitt, Danni Li. Back row, Rich Newell, Chris Luo, Jerry Sosinske.

Is your email address current?

BE A PART of the worldwide network of more than 65,000 College of Science and Engineering alumni. Stay in touch, get involved, and support the college.

We offer many events for you to connect with other alumni, which includes public lectures, Homecoming, CSE alumni gatherings, and reunions. Most invitations are sent via email, so make sure we have your current email address.

Visit **cse.umn.edu/update** to update.

FOLLOW US ON SOCIAL MEDIA

More than 4,700 students, alumni, and friends have joined us on the College of Science and Engineering Facebook page at: facebook.com/umn.cse. Also learn about recent news and connect with other alumni on Twitter at: @UMNCSE; YouTube at: youtube.com/umncse; LinkedIn at: cse.umn.edu/linkedin; and Flicker at: cse.umn.edu/flickr.

More than 80 CSE alumni attend networking event at brewery

PHOTOS BY ELLEN SORENSON

MORE THAN 80 CSE alumni gathered at the Tin Whiskers Brewing Co.'s taproom in Lowertown St. Paul, owned and founded by CSE electrical engineering graduates, Jake Johnson ('07), Jeff Moriarty ('08), and George Kellerman ('07), for an alumni networking event this fall. Christian Halvorsen (BME '13) and Adam Fitzgerald (BME '13) were among those who attended to experience the newly opened taproom, tour the brewery, and socialize with fellow College of Science and Engineering alumni. Watch for future alumni events on our website at **cse.umn.edu/alumnievents.**

Make plans to attend 50-Year Reunion for Class of 1965

IT'S NOT TOO EARLY to start making plans for the College of Science and Engineering's (formerly the Institute of Technology) Class of 1965 50-Year Reunion scheduled for May 14-15, 2015. If you graduated in 1965, mark the date on your calendar to reconnect with fellow classmates and celebrate.

Events being planned include tours, discussions, lectures, and more. You'll also have free time to explore what's new on campus.

The evening of Thursday evening, May 14, 2015 will feature a reception with your induction into the College of Science and Engineering Golden Medallion Society, which honors those alumni who have reached the 50th anniversary of their graduation. Alumni who were previously inducted into the Golden Medallion Society, including the Class of 1965 and earlier, are invited to attend the reunion on Friday, May 15, 2015.

Members of the Class of 1965 will be invited to join the academic procession during the 2015 College of Science and Engineering commencement ceremony later that evening on May 15.

Watch your mailbox for further details to be sent out early next year. Information will also be posted on our website at **cse.umn.edu/50reunion**.

SILVA YOUNG

Arthur Newman (ME '58) and John Copper (Aero '57) and Jody Wiggins attend last year's Class of 1964 50-Year Reunion and Golden Medallion Society celebration.

UPCOMING EVENTS

- **Emerging Professionals Network (EPN) Event at Bauhaus Brew Labs**
  Date: Tuesday, Nov. 18, 2014
- **CSE Alumni Gathering and Tour at Stratasys**
  Date: Wednesday, Nov. 19, 2014
- **CSE Public Lecture featuring Chemistry Professor Marc Hillmyer, Director of the Center for Sustainable Polymers**
  Date: Thursday, Dec. 11, 2014

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INVESTING IN Tomorrow

BY KIM DOCKTER
DIRECTOR OF EXTERNAL RELATIONS

Give students a competitive edge with *Fast Start 4 Impact*

KAYLA CHOATE

Ends December 2014! FastStart 4 Impact

I am pleased to announce that CSE donors have given more than $2 million to take advantage of the *Fast Start 4 Impact* program—the second highest amount at the University of Minnesota. Below are a few examples of how students benefited from these gifts.

Jeff Dean (CSci '90) and his wife, **Dr. Heidi Hopper** (Psych '90) endowed a scholarship in computer science to honor Vipin Kumar, a professor of computer science and engineering, who was Jeff's advisor. They hope their scholarship will attract women and underrepresented minorities to study computer science.

One of the first recipients, Katherine Applewhite, will graduate in May 2015 with a degree in computer science. Before enrolling in CSE, Katherine had never been exposed to computer science; however, after taking a class during her first semester and "seeing the wide variety of interesting problems that can be solved," she was convinced she wanted to major in computer science. Katherine chose software engineering/programming languages as her upper division track because, she said, "I'm really interested in developing and creatively solving problems to make something useful."

In her free time, Katherine is a member of the U of M Marching Band, works as a teaching assistant and writing fellow in the Department of Computer Science and Engineering, volunteers in the CLUES organization teaching English to adults, and is an active member of the campus swing dance club. "Receiving the scholarship really means a lot to me, and it will help get me through college," she said.

Russ (EE '57) and **Carol McNaughton** also took advantage of the *Fast Start 4 Impact* program by endowing a qualifying scholarship fund. Their first recipient was Brett Raisanen from Dassel, Minn., who comes from a family of 12 children. In a letter to the McNaughtons, Brett said, "Since most of my siblings still live at home, my parents cannot contribute financially toward my education, and I do not expect them to. Therefore, this scholarship is a really big help to me financially, and I greatly appreciate your generosity."

Brett adds, "I chose the University of Minnesota because the engineering program here is well-respected and provides a great education. Wanting to become a mechanical engineer was a decision I made as a freshman in high school, after taking higher level math, physics, and chemistry courses, and I have always enjoyed tinkering with different types of machinery at home." Brett graduated this past spring with a degree in mechanical engineering and is currently working as a product design engineer at Hutchinson Technology, where he completed a co-op last year.

Dr. Prakash Keshaviah (ME Ph.D. '74) endowed the Fred Shapiro International Student Fellowship in honor of his mentor, Dr. Fred Shapiro. He was the director of the Regional Kidney Disease Program in Hennepin County, where Dr. Keshaviah worked beginning in 1973. Awarded to international students, the first recipient is Saeed Hashemi, who began his Ph.D. program in mechanical engineering this fall. Saeed completed his undergraduate work at the University of Tehran, Iran. He has had several experiences on dynamic, vehicle dynamic, vibration, and rehabilitation robotics and plans to focus on rehabilitation and robotics in his graduate work. In addition, he is very interested in music and plays the Setar, a traditional Persian instrument.

Fast Start 4 Impact program ends December 2014

You can increase the impact of your scholarship by taking advantage of the *Fast Start 4 Impact* program. With *Fast Start*, you have a unique opportunity to:

- Create a new, named endowed scholarship supporting students.
- See the impact of your giving right away.
- Continue your legacy with a scholarship or fellowship in your name.

For each new endowment fund of $50,000 or greater, *Fast Start* will pay four years of annual scholarship awards to students in an amount that is roughly equivalent to what the payout of the fully endowed fund will be at the end of the four-year period. It is designed to build a permanent revenue source for student support and provide funds when they are needed most—right now.

The program was launched in September 2012 and **ends this December**. If you are considering endowing a scholarship or fellowship, I encourage you to take advantage of the *Fast Start 4 Impact* incentive program soon.

Your generosity will give our students a competitive edge and support their drive to invent, innovate, and solve the complex problems of today and for decades to come.

PTC provides major support for CSE programs and students

PTC, INC., ONE OF THE WORLD'S largest and fastest-growing software companies, is a major supporter of CSE's innovation and entrepreneurship.

"If we want America to continue to lead in the 21st century, there is nothing more important than a continued focus on innovation," said Jim Heppelmann (ME '87), PTC president and CEO. "By getting today's top students passionate about careers in STEM, we create the pipeline of talent necessary to develop the leading technologies that will continue to be the backbone of our economy as well as our security and quality of life."

Support for the Solar Vehicle Project

PTC's donation of PTC Creo, a computer-aided design software worth $2 million, proved to be a valuable tool in helping this year's Solar Vehicle Project team. Thanks to PTC Creo, the student team was able to model many parts of the car, from the shell to the battery casing and more. The software allowed the students to easily coordinate plans and even look back at previous years' designs for inspiration. Racing more than 3,000 kilometers across the Australian Outback, the team placed fourth in the 2013 Bridgestone World Solar Challenge in the Cruiser Class. The car, "Daedalus," now sits in the lobby of PTC headquarters in Boston.

Support for scholarships

Since Fall 2009, PTC has sponsored eight annual scholarships of $5,000 per year to students enrolled in the College of Science and Engineering. The scholarships are renewable for a total of $20,000 over four years for CSE students who participated in at least one full season on a FIRST Robotics Competition team in high school.

Frans Elliott is a CSE student studying electrical engineering and computer science who received a FIRST Robotics scholarship. "I had such a great time in FIRST, I decided I never wanted to stop working with robots," he said. "I plan to go to graduate school. Beyond that, I don't know whether I'll seek a Ph.D. and go into academia or just go into the 'real world.' No matter what I do, I want to work with robots because of FIRST and because of this scholarship."

Another recipient is Maggie Nelson, a CSE student who serves as the Society of Women Engineers outreach director. "Having been involved in FIRST Robotics, a continued desire to share knowledge and work in groups has driven me to stay involved in outreach events to middle and high school students," she said. "If I can inspire a student to pursue a new idea or start developing a passion for learning through teamwork, I have played a role in helping them discover their interests, as much as FIRST helped me find mine."

Engineering program support

In addition to supporting the Solar Vehicle Project and providing student scholarships, PTC gives financial support to a number of CSE engineering programs. Heppelmann also serves on the CSE Dean's Advisory Board.

"The University has played a big role in my life and my career. I met my wife there when we were both mechanical engineering undergrads." he said. "I always felt that the University of Minnesota armed me well to succeed in the business world. After a great career start out of college, two other CSE alumni joined me in starting an engineering software company. We had a lot of success together and after we were acquired by PTC, our software became the market leader and core to PTC's portfolio. Even though PTC is Boston-based with more than 6,000 employees, our top recruiting school has become the University of Minnesota College of Science and Engineering."

PHOTOS PROVIDED BY PTC, INC.

Jim Heppelmann (ME '87), PTC president and CEO, left, sits in the driver's seat of the University of Minnesota's cruiser-class solar racing car, which was the University's entry into the 2013 World Solar Challenge. The car now sits in the lobby of PTC headquarters in Boston. To view a video of the Solar Vehicle Project, visit **z.umn.edu/solarproject.**

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Retrospect

Kolthoff recognized for pioneering work

Widely considered the father of analytical chemistry, Izaak Kolthoff transformed chemical analysis from a qualitative to a quantitative science.

Built on the foundation of legendary pioneers, the University of Minnesota prides itself on excellence in the chemical sciences. One of those legends is Izaak Maurits "Piet" Kolthoff, who spent 64 years as a faculty member in the Department of Chemistry, and who is widely considered the "father of modern analytical chemistry."

His work in establishing the field of analytical chemistry as a scientific discipline was recently named a 2014 American Chemical Society (ACS) National Historic Chemical Landmark. This news coincides with the 100th anniversary of Smith Hall, the classic chemistry building on Northrop Mall, named after Professor Lee Irvin Smith.

Transforming chemical analysis

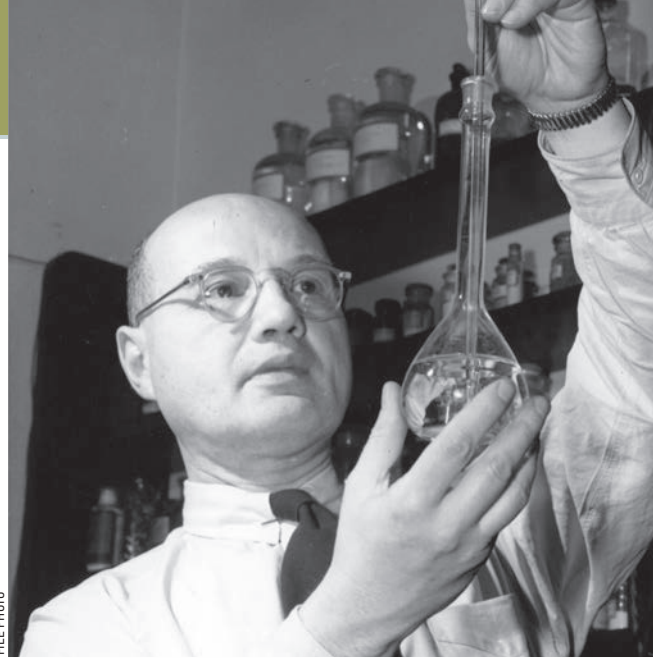
By applying fundamental physical principles and insights, Kolthoff transformed chemical analysis from a qualitative to a quantitative science and constructed a firm scientific foundation for analytical chemistry. His research changed the way scientists identify and quantify chemical substances, moving analytical chemistry from a collection of practical recipes and prescriptions to a branch of chemistry grounded on solid theoretical principles and experimental techniques.

Today, analytical chemistry is used in fields as varied as clinical medicine, environmental studies, forensics, and food and drug safety.

FILE PHOTO

Honoring a legend

Born in 1894, Izaak Maurits Kolthoff was known for his originality, insight, and timeliness of his published work. Kolthoff published his first paper in 1915 on pH, a new concept at the time. By 1918 he had already published 32 papers. From 1924-1927 he authored or coauthored eight textbooks and monographs. Over his career, he published more than 900 research papers and nine textbooks.



FILE PHOTO

Renowned at an early age

Before accepting his position at the University of Minnesota in 1927, Kolthoff had already gained a worldwide reputation.

Born in Almelo, Netherlands on Feb. 11, 1894, Kolthoff's first chemistry course in high school allowed him to develop a keen interest in the subject. This inspired him to create his own laboratory in his mother's kitchen. After graduating from high school, he entered the School of Pharmacy at the University of Utrecht in the Netherlands in 1911. Influenced by his mentor and professor Nickolas Skoorl, Kolthoff began to blend the qualitative and quantitative aspects of analytical chemistry. In 1915, he published his first paper on pH, a new concept at the time, and also received his apotheker diploma.

By the time Kolthoff earned his doctorate in chemistry in 1918, he had published 32 papers. After earning his doctorate, Kolthoff remained at the University of Utrecht for nine years, lecturing on electrochemistry, titrimetry, and precipitation.

In 1927, he accepted an offer from the University of Minnesota for a one-year term as a professor in the School of Chemistry, an appointment that quickly became permanent. In 1930, he became head of the school's analytical chemistry division. Although he officially retired in 1962, Kolthoff continued to conduct research, hold grants, and publish articles until his death, at age 99, in 1993.

Pre-eminent educator, prolific researcher, and writer

A dedicated but demanding professor, Kolthoff set rigorous standards for his graduate students, many of whom later enjoyed illustrious careers in academia and produced new generations of talented students. By the time he died, Kolthoff's academic descendants numbered more than 1,100. Of the numerous awards and honors he received, Kolthoff is said to have cherished most an award from the American Chemical Society for excellence in teaching.

Over the course of his career Kolthoff wrote or co-wrote more than 900 papers as well as numerous textbooks.With P. J. Elvin and others, he co-edited the

RICHARD G. ANDERSON

(Far left) Izaak Maurits Kolthoff works in his lab during the 1940s. (Left) Professor of Chemistry Peter Carr, who became a close friend of Kolthoff's when he joined the faculty in 1977, works in the lab with graduate students. Many concepts and methods originated by Kolthoff are being used by researchers today.

monumental multi-volume *Treatise on Analytical Chemistry*, the field's principal reference source. His influential *Textbook of Quantitative Inorganic Analysis*, first published in 1936, remains a landmark textbook in undergraduate chemistry education.

Kolthoff's work with acids and bases changed titrimetry from a practical art to an exact science. He is also credited in developing the polarograph, an instrument for recording polarization of electrolytes. Recognizing polarography for its scientific significance and practical importance led to the development of novel methods of environmental trace metal analysis and biological sensors. He was among the first scientists to understand the fundamental significance of crown ethers and their complexes.

Contributor to the war effort

Kolthoff's work that most directly affected the general public was in the synthetic rubber research program. It was the foremost chemical engineering project during World War II and created a huge synthetic rubber industry in an unbelievably short period of time. Kolthoff, whose family was devastated during Nazi occupation of the Netherlands, quickly assembled a large research group and made major contributions to the program. He and his coworkers held several key patents related to synthetic rubber. Nearly 200,000 tons of synthetic rubber were produced in 1943 and by 1944, the production rate was at 700,000 tons. Over the years the quality of synthetic rubber and the method of constructing tires were both improved, so today we have tires that will run for 60,000 to 80,000 miles compared to tires made exclusively of natural rubber that lasted only 10,000 miles.

Kolthoff's legacy

"There is no Kolthoff's Law, no Kolthoff Equation, no Kolthoff method for measuring the amount of X, Y or Z," said Peter Carr, chemistry professor, who became Kolthoff's close friend after joining the chemistry faculty at the University of Minnesota in 1977. "His significance, rather, is woven into the basic fabric of modern chemistry, especially analytical chemistry. His work with his student James Lingane on polarography laid the foundation for the major electroanalytical methods of amperometry, linear scan, and cyclic voltammetry. These methods are embedded in and enable the work of many current U of M chemists, including Kent Mann, Larry Que, Connie Lu, Christy Haynes, and untold numbers of chemists and chemical biologists around the world."

Carr noted Kolthoff's rigorous evaluation of chemistry gave way not only to better measurements, but to a research philosophy he imparted to his students and colleagues. "In these ways and many others I.M. Kolthoff's enormous influence shaped the teaching and practice of modern analytical chemistry," said Carr. "It would not be a mistake to say that hundreds of thousands of chemists and biological scientists use concepts and methods developed by Kolthoff but have no idea whose shoulders they are standing on."

In 2012, Kolthoff was posthumously inducted into the Minnesota Science and Technology Hall of Fame. Today, the Department of Chemistry continues to honor his legacy with the Kolthoff Lectureship in Chemistry.

BY EILEEN HARVALA

RICHARD G. ANDERSON

(Below) CSE Dean Steven L. Crouch and Senior Vice President for Academic Affairs and Provost Karen Hanson unveil a plaque on Sept. 12, 2014, honoring Kolthoff's contributions to the field of analytical chemistry as an American Chemical Society Historic Chemical Landmark.

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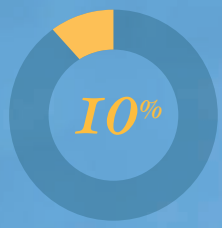

of all plastic is recycled

BY DEVELOPING NEW SUSTAINABLE AND BIODEGRADABLE MATERIALS, WE'RE PIONEERING THE NEXT GENERATION OF PLASTICS.

450 *years* is how long it takes a typical plastic bottle to decompose

Plastics are everywhere. Unfortunately, most of today's plastics are made from non-renewable fossil resources and largely end up in our landfills. Plastic waste also pollutes our lands and oceans. Researchers in the University of Minnesota's Center for Sustainable Polymers (csp.umn.edu) are working to find a solution by creating plastics made from renewable sources like plants. These new "green" plastics can be biodegradable and better for the environment. It's one more way the future is being Made in Minnesota.

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